RELATIVE CATCHES OF SNOW IN SHIELDED AND UNSHIELDED GAGES AT DIFFERENT WIND SPEEDS

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ABSTRACT

Some results are presented of a comparison of the observations of precipitation catch in pairs of standard 8-inch gages, one equipped with an Alter-type windshield and the other unshielded. The ratios of the catches of snow vary with the average daily wind speed. A generalized wind speed-catch ratio relationship based on previously reported observations is included.

1. INTRODUCTION

The precipitation gage catch is one of the primary items of observation in meteorology, hydrology, and climatology. How well the individual gage performs its task of measuring the amount of precipitation has been of concern since Heberden [2] found that similar gages close to each other but at different heights above the ground gave different catches.

Subsequent investigators have demonstrated that the gage performs its task less and less efficiently as the wind speed increases. In addition, at any given wind speed, the deficiency of catch increases greatly from the case of large raindrops to that of fine, dry snowflakes.

Many attempts have been made to devise protective shields which would eliminate the adverse effect of wind on the catch. None has been entirely successful. The two most practical and widely used are the rigid shield devised by Nipher [3] or a variant of it, and the flexible one devised by Alter [1] or a variant of it. The former is of trumpet-shape with flared end upward and at the level of the gage orifice. The latter is of similar shape but consists of loosely hung, movable metal strips. The Alter, or flexible type, is superior to the rigid type and has come into general use in the United States. The results of previously reported investigations of influence of wind speed on gage catch were summarized and an extensive bibliography was given by Weiss and Wilson [5].

Of those previously reported investigations, only two, Long [4] and Alter [1], compared directly the catch of an unshielded gage with that of a gage with flexible shield. In each of these cases the wind observations were not at the gage orifice. In the latter case they were seven miles away.

The aim of this report is to present the results of a comparison of the observations of catch of snow in four pairs of gages, one of each pair equipped with a flexible shield. The ratios of the catches of each pair are found to vary with the average wind speed. The anemometers were placed nearby and at the orifice level of the gages. The results are found to be in accord with general relationships based on the work of previous investigators.

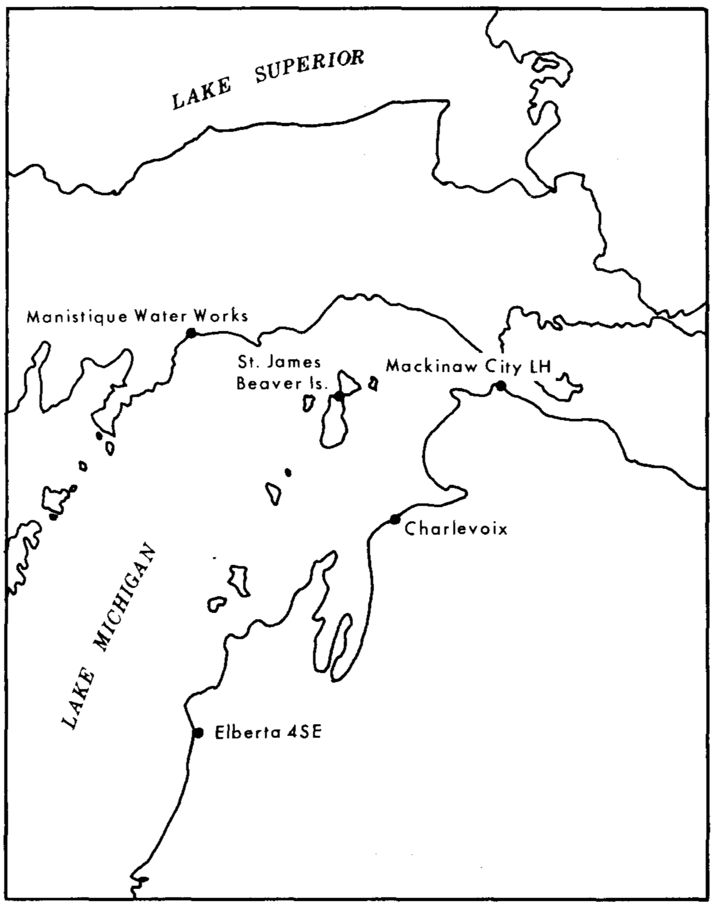

Figure 1.—Location of precipitation stations.

2. DATA USED

The data were obtained from the RH-4 Northeastern Lake Michigan precipitation project, a joint project of the Corps of Engineers, U.S. Lake Survey, and the U.S. Weather Bureau. The four Michigan stations used in this comparison are: Elberta, Mackinaw City, Manistique Water Works, and St. James, Beaver Island. Totalizing anemometers were installed in January 1956. The exposures were open with woods no closer than 100 feet in any case. Beaver Island is in the northern part of Lake Michigan, and the other three stations are on the shore of the northeastern end of the lake. All four are within a radius of 60 miles. The station locations are shown on the map of figure 1. The climatological record indicates that in this region the normal daily maximum temperature drops to freezing (32° F.) near the first of December and remains below until near mid-March. The normal daily average temperature drops to freezing by mid-November and remains below to about the first of April.

The data consist of daily observations at each station of maximum and minimum temperature, daily precipitation catch in the standard 8-inch gage, daily precipitation catch in an additional standard 8-inch gage equipped with an Alter-type flexible shield, and the daily wind movement in miles indicated by a totalizing anemometer. The anemometer was mounted near the gages with the bottom of the cups level with the gage orifice.

The data forms were filled out once per day by the observers. Since the character of the precipitation was not recorded, it is not known whether the catch was of snow or rain or a mixture. It is known that the influence of wind speed on the catch is much greater for snow than for rain. Also that when the temperature is below freezing, the precipitation is almost certain to be snow. For those reasons, the criterion was used that the catch was assumed to be snow if it occurred on a day on which the maximum temperature was freezing (32° F.) or below.

The observer reported the totalizing anemometer reading at the regular observation time. The daily wind movement is found by subtracting the previous day's reading. This difference divided by 24 gives the average hourly wind speed in miles per hour. This method, of course, masks the peak values of wind speed and increases the scatter of the plotted points when catch ratio of unshielded to shielded gages is plotted versus the wind speed. For this study, data used were for the period from the time of installation of the anemometers in January 1956 through December 1958. Only those cases were used for which the catch of the unshielded gage was more than 0.01 inch. For Elberta, there were 73 cases; Mackinaw City 45; Manistique 50; and St. James, Beaver Island 37.

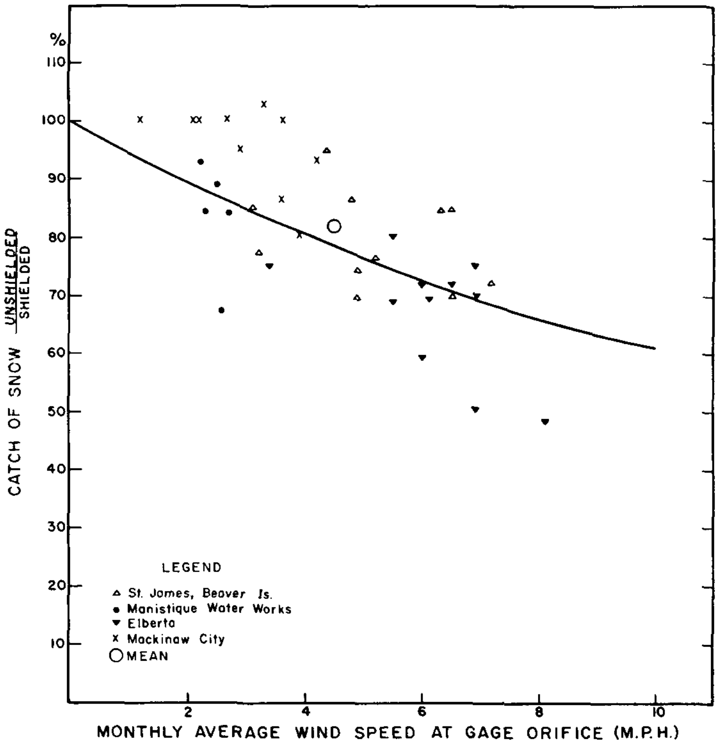

FIGURE 2.—Relation between monthly average wind speed (m.p.h.) at gage orifice and ratio of snow catch in unshielded to shielded precipitation gages. Data from February 1956 to December 1958, *inclusive*.

3. ANALYSIS OF THE DATA

Table 1 gives the ratio of the 5-year average catch of the unshielded gage to that of the shielded gage for the four stations mentioned above plus Charlevoix for the period 1954–1958. The latter station was not included in the rest of the analysis because of incomplete wind data.

The marked difference in the ratios for the part of the year when the temperatures are below freezing is an indication of the more deleterious influence of wind on the unshielded gage catch in case of snow. It is also a reflection of the improved catch of snow when the gage is equipped with the shield. The effect of the shield is less pronounced during that part of the year when the precipitation is usually rain.

For the four stations of this study, the ratios of the monthly total unshielded gage catch to that of the shielded gage for the months of December, January,

TABLE 1.—*Ratio (in percent) of unshielded to shielded gage precipitation catch. Data from five stations, 1954–1958.*

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Unshielded/Shielded (average %)	82	83	84	99	99	99	99	99	99	99	96	84
				temperatures above freezing								

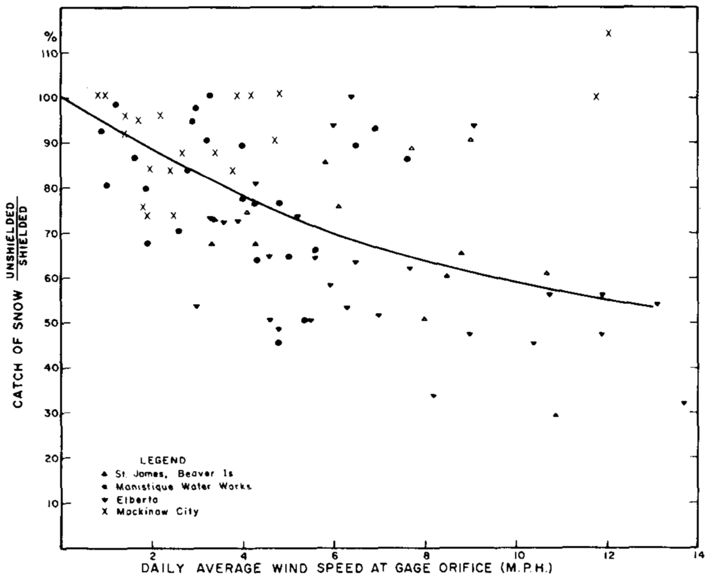

Figure 3.—Plot of daily ratio of unshielded to shielded gage catch of snow against daily average wind speed for cases when shielded gage catch $\geq$0.10 inch.

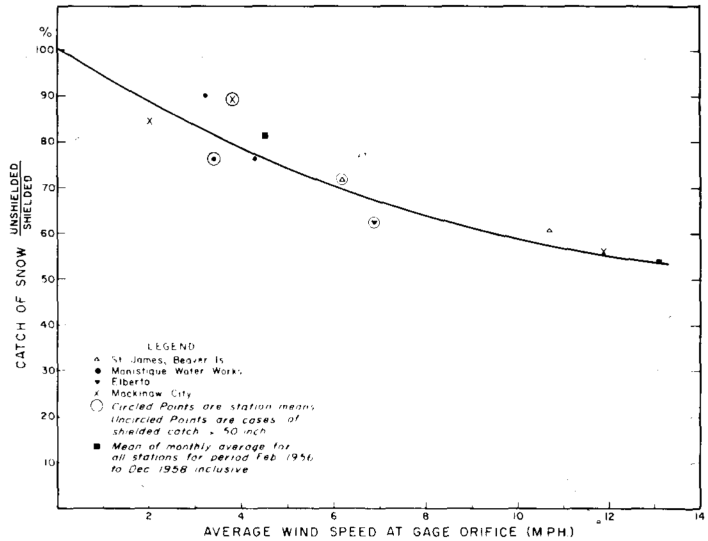

Figure 4.—Plot of mean ratios (unshielded to shielded gage catch) against average wind speed.

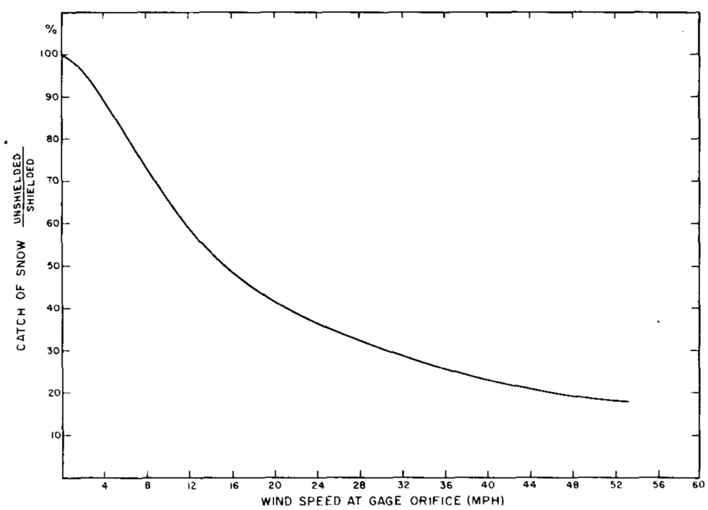

Figure 5.—Generalized relationship between the ratio of snow catch (unshielded to shielded gage) and wind speed at gage orifice, based on data of previous investigators.

February, and March when the precipitation could be considered to be mostly snow, were plotted versus the monthly average wind speeds. This wind speed was found by dividing the monthly anemometer totals of miles of wind by 24 hours times the number of days in the month. The data are plotted in figure 2. They suggest a decrease in the ratio with increasing wind speed for snow.

The plots of individual day ratios versus daily average wind speed for those cases where the daily maximum temperature did not exceed 32° F., and the unshielded gage catch was more than 0.01 inch show a large scatter which is probably partly due to the variability of the wind speed. This variability can be obscured in the daily average. In addition there is a large ratio variation when the catch is small. The scatter can be reduced somewhat and the trend made more apparent if only those cases are included where the unshielded gage catch is greater than 0.10 inch. These cases for all four stations are plotted in figure 3. Two of the points (for Mackinaw City) lie far from the general trend line. Both of these cases occurred during the first winter of record. When the shields were first installed they were placed with their tops several inches above the orifice of the gages. In September 1956, all the shields were lowered to set the tips of the blades one-half inch above the gage orifice.

To delineate the relationship further, mean values for the total period at each station and the individual cases where the daily shielded catch value was 0.50 inch or more are plotted in figure 4. A curve drawn to these points is considered to best express the inherent relationship between the catch ratio and wind speed.

4. COMPARISON WITH PRIOR WORK

A generalized relationship between the ratio of the unshielded to shielded gage catch of snow and the wind speed at the gage orifice is shown in figure 5. This curve is based on data given by the various investigators listed in the references of Weiss and Wilson [5].

The results of this investigation expressing the catch ratio—wind speed relation as determined from the Michigan station data, figure 4, show good agreement with the comparable portion of the general relationship curve of figure 5.

ACKNOWLEDGMENTS

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